Advances in Educational Technology and Psychology (2024)
Clausius Scientific Press, Canada

DOI: 10.23977/aetp.2024.080604
ISSN 2371-9400 Vol. 8 Num. 6

Exploring XR Games in English Instruction: A Systematic Review of Empirical Studies

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Keywords: ESL Instruction, Systematic Review, XR Games

Abstract: Extended reality (XR) technologies (VR/AR/MR) have propelled a paradigm shift in the field of ESL teaching and learning. This study summarizes the evidence and development of XR games in ESL instruction in Chinese Mainland and reveals its overview and development trends and research implication. This paper presents a holistic review and analyses 17 articles published between 2013 and 2023 that are indexed in the Web of Science Core Collection. XR-powered game-based language learning was mostly applied at the tertiary education. They primarily focused on vocabulary, followed by general English, writing. Papers reviewed focused on AR than VR or MR. Concerning sample size, 8 articles reviewed reported large. The review unravels the trends, gaming characteristics and game engines of contemporary XR games. AR and VR technologies assisted language learning mainly by immersing learners in a virtual world with 3D images, videos and games. Terminal equipment, portable or mobile devices, tablets and computers are most widely used devices to augment a real environment. All the studies were identified to be self-developed to explore the design and development of XR-supported game-based learning environments. OpenSimulator, Unity 3D, ARIS, Java 1.7, Android SDK, Wikitude SDK, JigSpace, 3ds Max software are common game engines. The results reveal that integrating XR games benefited English learners in terms of cooperation, motivation, enthusiasm, engagement, immersion and presence, and the development of four English language skills and knowledge. Research recommendation for implementing XR games in ESL instruction for institutions, researchers, and educators is also discussed.

1. Introduction

It is undeniable that learning English well has become a significant part for learners at various educational levels in Chinese Mainland. In this increasingly globalized world, learning a foreign language well can help job candidates make progress in their career, become aware of other cultures and help them to increase understanding and knowledge of their own language[1]. English language proficiency is a critical skill for one's academic success. The rapid development of information and communication technology has propelled a paradigm shift in the field of English as a Second

Language (ESL) teaching and learning. As digital technologies have advanced more rapidly, game-based learning is emerging into the field of language education worldwide.

In order to explore the value of games in cognition and education, the Education Game Professional Committee of the China Education Technology Association was established in 2015, which is mainly dedicated to game platform construction, game teaching workshops and educational serious game design and research. Ten innovative pedagogies were selected by The Open University in collaboration with the Centre for the Science of Learning and Technology in Norway in 2019, among which game-based learning, i.e. playful learning, ranked first. Microsoft's "Games-to-Teach" project is run at MIT through iCampus, concentrating on the interactive and immersive potential of digital games.

Recent years have witnessed the application of digital games in ESL teaching and learning in China. Canada and China are among the list of countries exploring the possibility of embedding AR, VR, MR technologies into the learning and teaching processes [2]. Integrating XR technologies in the ESL instruction has substantially improved English learning and teaching experience. Games in learning (often referred to as serious games) have the potential to make learning more student-centred, engrossing, enjoyable, interesting and thus, more effective and efficient[3].

Previous reviews have mainly identified the benefits of AR or VR or XR technologies in language learning or English learning. The research of applying XR games in English language learning have not been explored yet. This study explores the latest advances of XR games and educational games and summarizes the development of XR game practice in ESL instruction in Chinese mainland in the past decade.

Notably, the existing reviews in Web of Science Core Collection (WoSCC) have concentrated on immersive technologies like VR or AR or XR in higher education, preschool education, or second language acquisition or sports or engineering training. Though there are ample researches exploring XR games in the education sector, there is a shortage of holistic reviews investigating the applicability of XR games in ESL instruction encompassing all educational levels from preschools to tertiary education, let alone in Chinese mainland.

In order to further understand how VR/AR/MR influences language learning from research perspective in accordance with the latest technical trends, this paper will systematically review the research on the application of VR/AR/MR games in English language learning. Compared with the previous research, it provides a detailed and systematic review of the development trend of the model elements over the past 10 years, including publication distribution by year, learner groups, areas of English learning, forms of XR, sample size, gaming characteristics, game engines for designing XR games.

By identifying the trends of latest research into XR game integration in ESL instruction in the past decade in Chinese Mainland, the paper intends to uncover XR game's potential and puts forward its implications for institutions, researchers and educators. To achieve these goals, we seek to answer the following research questions:

(1) What trends (annual distribution of primary studies, learner group, areas of English learning, forms of XR, sample size) are present in research on XR games in ESL instruction in Chinese Mainland?

(2) What are gaming characteristics of XR games in the study?

(3) What game engines are reported in the literature?

(4) What recommendations can be made to integrate XR games into ESL instruction?

2. Literature Review

2.1. The XR Framework

The term "XR" is an umbrella term that covers various simulation-based technologies such as Virtual Reality (VR) and Augmented Reality (AR) and Mixed Reality (MR). XR enables seamless interaction between virtual and real environments, thus creating a new learning experience [4]. Some hold that XR educational application scenarios relate to: (1) smart education product design; (2) implementing game-based learning; (3) constructing smart learning environment; (4) design education; (5) special education[5]. Some studies have investigated the effectiveness of XR game application in a wide variety of disciplines, such as maths, language, biology, art, history, physics, music, healthcare, physics, and blended education.

VR refers to 3D virtual worlds simulating realistic scenarios, generated by advanced computer technology, which provides learners with opportunities to practice their language skills in immersive and interactive scenarios. VR technology was invented in the early 1960s, but did not attract much attention for a long time. Recently, VR has made tremendous technical progress and keeps flourishing in the digital world. And there are different types of virtual reality experience available [6].

AR is seen as a three-dimensional digital technology that blends both the virtual and real worlds seamlessly to enhance learners' understanding of the actual world with simulated items. It's utilized in popular apps like Snapchat filters and Pokémon GO. As contextualized learning aids students in understanding and applying what they have learned to attain knowledge internalization, especially in English as a foreign language context [7].

MR, a term that gained prominence in recent years, incorporates aspects of both AR and VR, allowing physical objects and virtual elements to co-exist and interact in real time, creating immersive experiences that seamless blend the digital and tangible realms. It's widely used in gaming, employee professional training and education setting.

2.2. XR Games

XR games cover everything from VR, AR to MR games, which offer a promising opportunity for innovation in the ESL teaching and learning process by integrating virtual objects into real worlds. Various digital technologies are currently available for implementing XR gamification. A growing number of Chinese educational institutions at all levels have also been developing and promoting the practice of XR games. They either employ existed apps or digital platforms in English, maths, science, engineering, medicine, history, art and other disciplines, such as Word Talent, Shanbei Vocabulary, Duolingo, Memrise, Hellotalk, FluentU, VirtualSpeech and so on, or design their own XR games.

In tertiary education, virtualized foreign language teaching and learning is still at an initial stage. Virtualized foreign language teaching and learning facilitates learners' multisensory participation and strengthens the perceptual and experiential effect, thus making language learning more effective and enhancing the competence of language learners. VR games have been applied in VR-situated Business English training and English public speeches.

As regards commercial VR games available, *Food Force* and *Quest Atlantis*, although the designers would not have built the game specifically for language teaching purposes, they would have purposefully designed pedagogical structures into them[8]. Affordances for vocabulary learning are found in these serious games.

Specifically speaking, VR games are designed to assist users in grasping the concept of a specific subject, to expand their knowledge and facilitate participation. Modern educational games

are played with high-end video technologies such as stereoscopic 3D, or through a Head-Mounted VR environment[9]. These technologies use a spatial depth on the screen and offer rich, motivating and meaningful learning experience for the users.

The popularization and development of smart mobile devices serve as a convenient platform for the application of AR educational games in teaching, and AR educational games will usher in a new wave of educational technology research. ABRA, an AR English word game software, developed by Concordia University in Canada, has carried out fruitful experiments in Canada, Australia, China, Hong Kong, and other countries and regions, which focuses on natural spelling and aims to assist students in improving English reading ability in the Chinese context [10]. The application of AR in school settings has been supported by several researchers as a positive indication for improving learners' self-efficacy[11], critical thinking[12], cognitive load, and motivation[13].In this game, learners at Ganyu Huajie Bilingual School in Jiangsu Province, select virtual 3D characters through augmented reality and the characters are generated in the real environment where learners interact with characters through situational quizzes.

Despite the growing research and recognition of MR-assisted game-based learning, this approach has received limited attention in EFL instruction. Qiu et al. reviewed 2008—2019 research on immersive language learning, finding no MR-applied cases [14]. Similarly, Li and Wong reviewed 2004—2018 studies in the same field, identifying far fewer studies on MR than on VR and AR [15].

Therefore, this article is contextualized in having a holistic view of XR game research in English learning and teaching in Chinese Mainland, providing insight into the implication of applying XR games in ESL instruction from preschools to universities in Chinese Mainland.

3. Data and Methodology

This review focused on research into the application of XR games in ESL instruction in Chinese Mainland that was conducted between January 1, 2013 and December 31, 2023.

To ensure the quality of the materials quoted and the relevance of the research topics, we first established a strategic search method based on effective scanning of the most relevant literature. This paper explores research articles on XR games in ESL instruction in Chinese Mainland collected via the Web of Science Core Collection (WoSCC) database for the period 2013—2023, inclusive. The search terms and expressions for the targeted articles are as follows: ("virtual reality game" OR "augmented reality game" OR "mixed reality game" OR "extended reality game" OR "VR game" OR "AR game" OR "MR game") AND ("second language" OR "language learning" OR "English" OR "language education" OR "language acquisition").

To select the right targeted papers for this review, the inclusion and exclusion criteria were stated as follows:

(1) Document types were limited to empirical studies. Additionally, the articles are written in English. The targeted articles should focus on English teaching and learning and contain detailed information about the learner groups, procedures, original research data, research design and findings.

(2) The research context must be set in Chinese Mainland. There were no constraints that the research should be conducted by Chinese scholars or institutions, but the studies should be related to the XR game application in Chinese Mainland. Moreover, the study region has excluded Hong Kong, Macau, Taiwan in China, since these areas have unique education systems and technologies.

(3) The research must focus on XR game practice as some only mention digital games in the text but specific XR technology has not been explicitly mentioned. These papers have been excluded.

(4) Book chapters are not stand-alone studies. Therefore, they were not included for analysis.

Our first search phase provided 167 papers from which we excluded 71 duplicates and review

papers and articles that did not involve XR. Then, the full texts of all the articles were read and rechecked carefully. This left 17 WoSCC articles for the final review.

4. Result

As is presented in Figure 1, the number of papers published on this topic per year has fluctuated from 2013 to 2019. There was no study in 2013 and 2016 and the articles increases to 3 in 2019. The bar chart shows a stable increase in the number of research papers dedicated to XR games in ESL from 2020 to 2023. It peaked in 2022 and 2023 (n=4). It should be noted that the rapid increase in the number of publications per year is driven by the rapid advances in high-speed communication and computer technology as well as growing interest on how VR, AR or MR related smart technology can help with various aspects of second language acquisition.

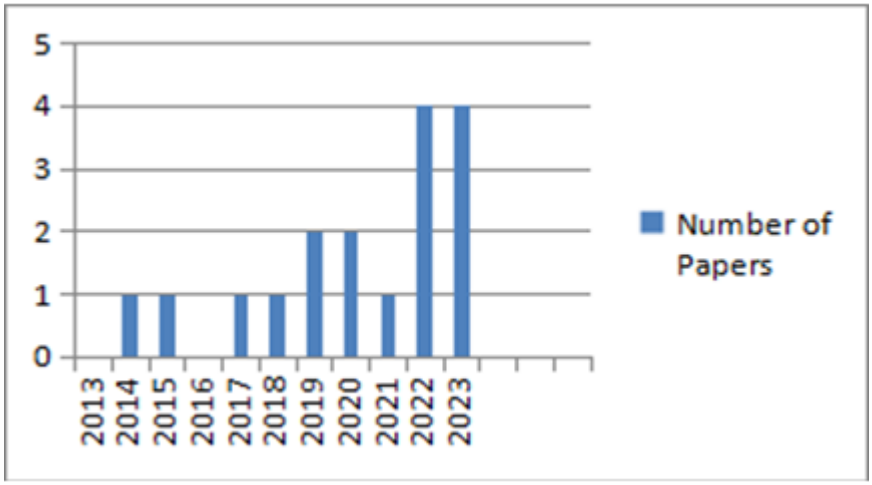

Figure 1: Annual distribution of primary studies.

Concerning the learner groups, among the 17 papers that we reviewed here, a total of 8 were conducted among university students, followed by the primary schools (n=5), secondary schools (n=2) and preschools (n=2) (Figure 2). The conclusion aligned with Luo et al.'s (2024) research findings that XR-powered game-based language learning was mostly applied at the tertiary level[16].

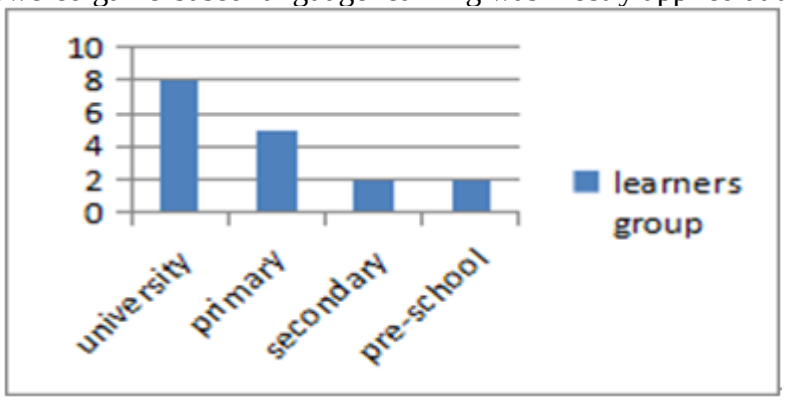

Figure 2: Learners group.

One prior study suggests that AR, VR and XR technologies can be used not only for teaching a particular language, but can also be used to teach various subjects and languages in different contexts[17]. Regarding the aspect of English teaching and learning on which the studies concentrated, Figure 3 indicates that they are primarily entered on vocabulary (n=6), followed by general English (n=2), writing (n=2). While topics like speaking, reading, grammar, pronunciation,

multimodal apology, learning presence and intercultural competence received minimum interest with one VR game each.

Vocabulary is central to language acquisition, and Chinese learners often place great emphasis on vocabulary learning because they frequently get stuck by limited vocabulary in writing and speech. Vocabulary plays a fundamental role in second language acquisition and is as important as the five main basic skills of listening, speaking, reading, writing, translating. Gamified AR and VR tools were often utilized for vocabulary learning. This result is consistent with the previous review study conducted by Huang (2021) [18]. In his review, a total of 28 out of 88 articles adopted AR/VR tools to build rich vocabulary.

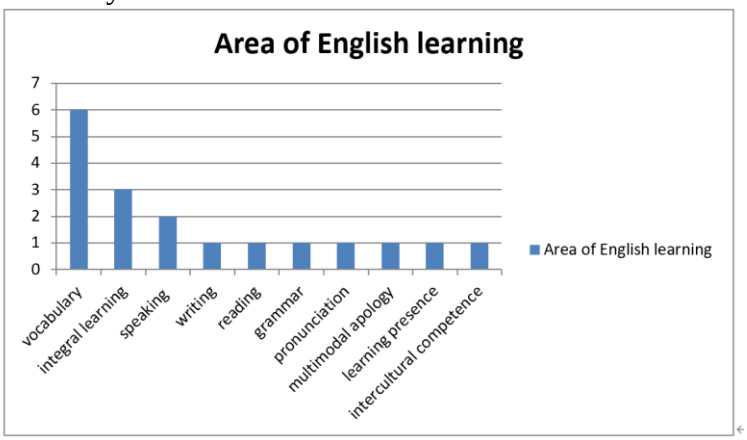

Figure 3: Areas of English learning.

Figure 4 shows that more of the papers reviewed focused on AR (n=9) than VR (n=7) or MR (n=1). Fortunately, the selected articles provided clear message about the forms of XR. This result is consistent with previous review studies on the similar topic. So far, little attention has been paid to the research and practice of MR-assisted educational games.

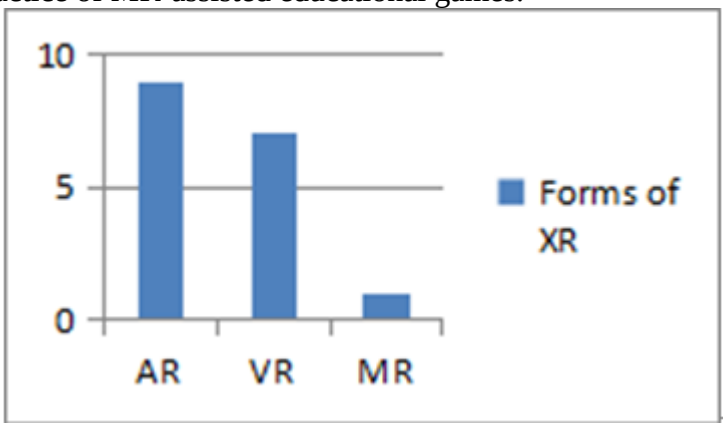

Figure 4: Forms of XR.

According to Burston's[19]categorization of sample size— which consists of "very small" (n<15), "small" (n=15~25), "medium" (n=25~49), "big" (n=50~64), and "large" (n>64) — a large majority of the XR articles reviewed reported large (n=8) or medium (n= 6) samples, as shown in Figure 5.

In light of the profound influences, XR games have been widely applied in various aspects of English and different educational stages, which is listed in Table 1, which provides details of the selected articles including game name, forms of XR, author, year and gamified activities.

AR and VR technologies assisted language learning mainly by immersing learners in a virtual world with 3D images, videos and games as proved by Huang's review results. In some studies, AR

and VR videos were used to enhance language learning.

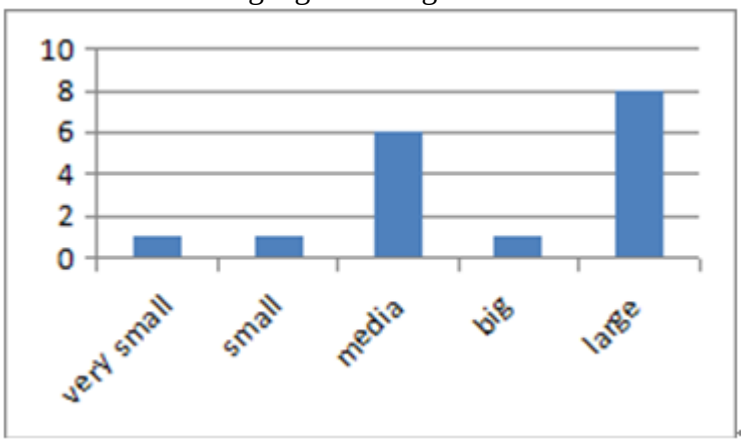

Figure 5: Sample size.

Table 1: Gaming characteristics of XR games.

Game name	XR	Author/Year	Gamified activities
Digestive System Vocabulary Knowledge Scales (DS-VKS)	AR	Jia et al., 2023	JigSpace app, Quizlet app, AR flashcards game, a matching game
Custom-developed AR game app	AR	Liu et al., 2023	Interactive exercises, cultural challenges, scavenger hunts
FancyBook AR game	AR	Zuo et al., 2022	Situated learning in AR fantasy cards, storybooks, phone applications
Handwriting recognition AR application	AR	Xu et al., 2019	Match the specific building, a matching game, find the way
Custom-made AR-based application	AR	Zhou, 2017	Scan AR cards, click on the screen, press the model, watch videos
Knowing Your Phonetic Friends	AR	Hu et al., 2022	Virtual teacher feedback, point acquisition, find clues and reasoning
Geolocation-based scavenger hunt	AR	Mei & Yang, 2019	Follow the in-app clues to reveal destinations, read instruction, document them, solve puzzles
Solar Explore	AR	Liu et al., 2018	Rearrange the marker cards, read facts about the planets, a pair game
Spherical Video-based VirtualReality (SVVR)	VR	Huang et al., 2020	Watch spherical videos, view stories, collaborative learning, discuss tasks
Digital Game-Virtual College	VR	Xiao & He, 2023	Words Arena Contest, Words Talents, word TV, word broadcasting, a reflective report, role play
VILLAGE	VR	Wang et al., 2015	Role play with chatbots, time machine providing scaffolding instruction, conversations, quizzes
Mobile VR game app	VR	Xie et al., 2022	Voice interaction, AI evaluation, immersion-based learning
VR English game	VR	Huang, 2018	Role play, get scores and ranks, receive a hint
Spherical Video-	VR	Liu et al., 2022	Watch SVVR videos, read the articles, questions,

Based Virtual Reality (SVVR)			get feedback
Virtual learning environment	VR	Barrett et al., 2021	Controlled practice, free practice
WebXR	MR	Pei et al., 2023	A reward, robot-assisted language learning a quiz game, a companion agent
Mobile AR application	AR	Zhu et al., 2014	Scan the word, present matched pictures

After analysing all the papers, all experiments incorporated some XR-assisted gamified resource especially custom-made for the study, which made it easier for learners to acquire course-related knowledge and skills online with the gamified learning resource. The seventeen XR games reviewed in this study differ significantly in the learning devices. Terminal devices, portable or mobile devices, tablets and computers are most widely used to augment a real environment by presenting virtual scenes to improve users experience in twelve studies. In the other five researches, learners, equipped with HMD (Helmet-Mounted Displays) like HTC VIVE Focus, HTC Vive Tracker, can interact with immersive environment without interruptions from the outside world. Typical gamified activities include scanning AR flashcards, interacting with virtual teachers, role-playing with chatbots, role-playing the plot, watching SVVR videos, a matching game, etc. Additionally, some experiments are conducted with free applications, JigSpace app or Quizlet app, which can be accessed or downloaded on the Internet on a computer or a mobile device. The results indicate that the application of XR games with English learners is a purely positive experience.

All the studies were identified to be self-developed to explore the design and development of XR-supported learning environments (Table 2). Two VR games were custom-made with game engines, such as OpenSimulator[20]; Unity 3D[21]. Five AR games were self-designed with ARIS [22]; Java 1.7, Android SDK[23]; Unity 3D[24]; JigSpace and Quizlet[25]; Unity3D and 3ds Max software. Take ARIS as an example, this is a free and open-source digital platform, an innovative technical tool to design mobile AR-based learning and teaching. Unity 3D is a popular game engine with XR tools that empowers research and development teams to create interactive and immersive game experiences with a powerful set of tools, allowing users to create simple geometric objects such as spheres, cubes and rectangles.

Table 2: Games engines for designing XR games.

Game type	Game engines	Author/Year
VR game (VILLAGE)	OpenSimulator (an open-source virtual world platform)	Wang et al., 2015
VR game (Virtual College)	Unity 3D (a game engine to create AR or VR applications)	Xiao & He, 2023 Xu et al., 2019
AR game	ARIS (a free and open-source platform)	Mei & Yang, 2019
Mobile AR	Java 1.7, Android SDK Wikitude SDK	Zhu et al., 2014
AR application	Unity 3D	Xu et al., 2019
AR game (DS-VKS)	JigSpace	Jia et al., 2023
AR game	Unity3D, 3ds Max software	Hu et al., 2022

Unity3D allows users to import models created by other 3D programs such as Maya, CATIA, and 3ds Max. It offers different types of licenses depending on the additional features [26].

5. Recommendations for implementing XR games in ESL instruction

5.1. Self-designing XR games by integrating smart technologies

Currently, emerging smart technologies—including mobile technology, augmented reality, virtual reality, artificial intelligence—evolve to thrive, and wearable technology have been integrated into XR games, such as HMD, HTC Vive tracker, an Oculus Rift, making gamified learning environments more intelligent and interactive. The flourishing educational technology is driving the sustainable development of gamification in education.

In the EFL context in Chinese Mainland, students often utilize multiple popular game-based vocabulary learning apps in their daily vocabulary learning to brush up on vocabulary, such as Bancizhan, Shanbei vocabulary, Duolingo, Quizlet, etc. Some researchers abroad capitalize on popular MMORPGs like *World of Warcraft, Second Life, The Sims*, or incorporate game-based learning resources to teach a foreign language. However, note that a total of seventeen XR games were self-developed or custom-made by institutions or experts or teachers in the study. Streitz Mayrath et al.'s statement may account for the reason why the use of virtual worlds should be directly relevant to the course context and closely tied to objectives[27]. Also, the designers should invariably involve the target learner groups into the design process, asking for their preferences and feedback for the game concepts, and taking their player types, learning skills and knowledge level into consideration[28]. DIY XR games should be a trend to meet the diverse demands of learners at all educational levels in Chinese Mainland.

Educators and developers might therefore focus on designing interactive and engaging virtual learning environments compatible with high-immersion VR systems, e.g. complete immersion in the first instance (both the physical properties of immersion such as sensory stimulation, and the psychological factors such as those proposed by Jennet et al.[29]). AR may potentially facilitate greater bodily engagement, multisensory perceptions, and interactions with the environment. These features are characteristic of embodied learning, potentially enhancing engagement and physical exploration for students adopting AR platforms. Therefore, it is urgent that educational institutions should provide professional training or workshops regarding how to integrate XR technologies with English teaching content to unlock every learner's potential. Meanwhile, with game engines identified in current review (e.g. OpenSimulator, ARIS, JigSpace, Unity 3D, 3ds Max software), XR game developers should work with instructional designers, story designers, game designers, language educators, subject matter experts to design quality, interactive and immersive XR games that enable learners to complete tasks in simulated real-world scenarios constructed by XR. Plus, it is necessary to strengthen collaboration among institutions further to share quality resources and achieve complementary advantages in the future.

5.2. Blending interdisciplinary curriculum content with XR games

Currently, gamified language learning has shifted from a single disciplinary perspective to an interdisciplinary one. The integration of language games with subject content, such as games with history, technology, nature, military, engineering courses, etc., has led to a continuous increase in interdisciplinary research. They might be embedded in commercial CALL programs, sites, or service like DuoLingo, Busuu, or LingroLearning.

In the educational setting, there currently emerges a growing research interest in integrating mobile augmented reality (AR) and the gamification concept to promote environmental education (EE) and sustainable development. Mei & Yang (2019) designed a geolocation-based mobile environment called AR scavenger hunt for an English writing course to explore students' perception of embedding technology-enhanced and gamified EE in their language learning process. This

approach can raise students' environmental awareness and subject content knowledge in a compelling way. Meanwhile, a paper worksheet purposefully phased about the biodiversity and sustainable lifestyle, is also created. Students discuss how some facilities on campus reflect the traditional Chinese ancient doctrine of harmony between man and nature.

Similarly, Lucas Gillispie, an American high school teacher in a high school in North Carolina, embedded the MMORPG *World of Warcraft* into the public school curriculum. He creatively integrates writing, mathematics, literature, leadership, public opinion, digital citizenship into the game plot and implement gamified courses entitled "WoW in School: The Hero's Journey". Three kinds of tasks are assigned in the course: tavern discussion (course content, grammar, and spelling), action feedback, hero logs (reflective writing), myths and legends (textbook knowledge and extracurricular reading materials), then creating an environment that provides constant feedback. Gillespie created a teaching website entitled WoW in School, giving instructions on how to integrate the game with classroom teaching[30].

5.3. Improving English teachers' digital literacy

Applying XR games to the field of English education is a rapidly evolving field. Therefore, the English education scenarios are developing and changing dynamically. The focus of ESL has shifted from acquiring basic skills to cultivating students' creativity, critical thinking and problem-solving ability. English teachers should be seen as designers of XR games with the aid of smart technical tools, integrating citizenship education, poetic culture, traditional culture, historical knowledge, IT skills, etc. into language games.

It should be acknowledged that although game-based learning in English language teaching is a combination of education and entertainment, an innovative form of teaching, but currently there exist some difficulties in integrating games into language learning courses. The factors that hinder the successful implementation of game-based learning in language course include lack of gamified learning resources suitable for course themes, shortage of funds and courses, inflexibility and insufficient professional development of teachers, etc. (Baek, 2008)[31]. Hence, cultivating game literacy for English teachers is a top priority, enabling learners to interact with virtual objects in a playful approach.

At its core, digital game literacy is considered a type of computer literacy, and is commonly defined as a narrow concept that refers to the ability to operate a mobile device, PC, or console and start, play, and end the game. Game literacy would be enhanced by playing games, participating in game communities, and creating resources for those communities, for example, a review, strategy guide, or walkthrough of a game. Chen et al.'s (2020) findings put forward five key capabilities in game literacy required by teachers. They include (1) basic game literacy; (2) high-level game literacy; (3) instructional design for GBL; (4) organization and management for GBL; (5) evaluation of GBL[32]. Furthermore, English teachers can attend workshops or player forums regularly to know more about game implementation requirements, course constraints with an effort to modify or build a game with tools and resources like videos, wikis, software, and so on. In addition, teachers and educators can discuss how to teach English with existing digital games.

6. Limitation and Future Research

This study conducted a comprehensive review of research on the application of XR games in ESL instruction between 2013 and 2023. To the best of our knowledge, this is the first review to provide a holistic and comprehensive insight into XR gamification in English teaching and learning in Chinese Mainland. However, the present review does have some technical limitations. Although the authors wanted to obtain as much research as possible on XR educational games, the articles

reviewed in this study were limited to journals indexed in the database: WoSCC. Other databases are excluded, which may result in some papers concerning XR game research not being covered. Secondly, this study is limited to the experimental studies presented in the form of complete articles, such as conference papers or journals, therefore, some studies that do not provide the full text may be excluded. At the same time, because the research was limited to papers written in English, studies published in other languages have been neglected.

Since XR technologies were relatively new, how English teachers corporate XR games in ESL teaching in Chinese Mainland should be further explored. Regarding the research design, researchers intended to enlarge the sample size and include other languages, such as Chinese, Japanese, Russian in future studies for XR gamification studies. There is a need to develop a framework for the adoption of XR games for English language teaching to ensure that XR-powered game-based educational activities more accessible and effective.

Acknowledgements

This research is funded by Guangdong Planning Office of Philosophy and Social Science, 2024 (no.GD24WZXC02-03), Education Research Project of Guangdong Province Office of Education, 2022 (no.2022GXJK277), Characteristic Innovation Project of Colleges and Universities in Guangdong Province, 2024 (no. 2024WTSCX144) and Teaching Academic Program in Guangdong University of Finance, 2024 (no.10).

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